

Exploring Meaning Making: Multimodality and Activity Theory as Complimentary Research Designs

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Abstract: One common problem in social science is to capture the process of meaning making from both the cognitive and the social/situational perspectives. This paper argues that a combination of Activity Theory and Multimodality can be effective as each have methodological strengths that allow this dual focus. The paper then discusses the application of this proposed methodology to a University Engineering degree class where the students were set the task of building a model bridge.

Keywords: Activity Theory; Multimodality; Meaning Making.

1. INTRODUCTION

One challenge in social science research is to capture the process by which meaning making takes place. One aspect to this problem is that while understanding can be observed in our actions, the actual process is cognitive. Since this is inherently psychological in some traditions, such as behaviourism, conducting such an enquiry is seen as being impossible (Mills, 2000) since the process cannot be directly studied (Popper, 1994). On the other hand, some aspects of psychology have developed concepts such as ‘verbal protocols’ that rely on people verbalising their decision making processes (Newell, 1990). In this case, observation of the reported thinking process is held to allow study of the internal thinking process. However, this leaves a gap between observation and process (Bem & Looren de Jong, 2006) and many theories derived from this perspective (in psychology often called ‘descriptive’ or ‘normative’) adopt a circular argument weakening the predictive value of such models (McAndrew, Gore, & Banks, 2009). Jewitt (2008) suggests that one solution is to combine the concepts of Activity Theory (Engeström, 1999; Kaptelinin, 2013; Leontev, 1978) with approaches drawn from multimodal analyses (Halliday, 1978; Jewitt, 2005; O'Halloran, 2011b).

The Soviet psychologist, Leontev (Leontev, 1978) sought to approach the problem of understanding the interaction between observed actions and mental processes by stressing the importance of the interaction of mind and activity. In this, he developed Vygotsky's earlier concept of Social-Cultural Theory (Vygotsky, 1962) to argue that the key way to understand human cognition, and thus meaning making, was in context and in the way in which the act of meaning making changes both the focus (object) of the meaning making and the understanding of the actor (subject) who is doing the meaning making (Kaptelinin, 2013). In Leontev's model the main actor is usually an individual, even if they are collaborating with others in the performance of a task and perhaps carrying out that task either for the benefit of a different group or at the direct command of another person (Leontev, 1978).

Engeström developed this approach by placing more emphasis on the wider group sharing a task or the wider social group (which he describes as a community) that influence meaning making (Engeström, 1999). In addition, he maintained the

emphasis already placed by both Vygotsky and Leontev on the importance of the tools available as one way in which a task can be understood. His elaboration was known as Activity Theory (AT).

The focus in AT on tools, focus, other people and purpose all help place the cognitive process of carrying out a task in context. Where a gap remains is in consideration of how meaning making is shared and indicated. In this respect, concepts from multimodality help fill this gap (Iedema, 2003; O'Halloran, 2008) as it draws together how speech, gesture and tools are used to build up and share meaning.

Multimodality is derived from Halliday's work on semiotics where he argued for the importance of context in defining meaning as opposed to the traditional focus on grammar and word use (Halliday, 1978). However, Halliday paid little attention to the importance of non-verbal gestures (O'Halloran, 2008) and his approach was expanded to the concept of *Multimodal discourse Analysis* (MDA) to capture other modes of social interaction (O'Halloran, 2008) such as vision, gesture, colour, setting and abstract notation systems. As MDA has developed, an important issue is how different semiotic resources interact and how to take account of the wider context. Inter-semiosis (O'Halloran, 2008) has become the means by which different semiotic tools are combined and usually in a given situation one mode is dominant (Kress & van Leeuwen, 2006). Re-semiosis, in turn, is the process by which meaning shifts due to the wider context as alterations to both context and social space change the process by which meaning is built up (Iedema, 2003) and the interpretation placed on specific words or gestures.

However, in practice, the concept of re-semiosis is rarely applied in multimodal transcription and analysis (Jewitt, 2005, 2008) leaving an important gap as: "social semiotics and multimodality offer conceptual tools for the analysis of meaning making. This leaves out the socially situated character of meaning making" (Jewitt, 2005, p. 16).

In effect, the two approaches of Activity Theory and multimodality can be seen as mutually supporting (Jewitt, 2008). Activity Theory has a richer set of tools to capture the context within which meaning making takes place and actions are interpreted. Multimodality in turn allows a closer focus on how that meaning making is undertaken and how it may vary.

2. LITERATURE REVIEW

As discussed in the introduction, the focus in this paper is to consider the practical implications of adopting Jewitt's (2008) suggestion that Activity Theory and Multimodality can be effectively combined to improve our understanding of the meaning making process.

However, Activity Theory has complex roots. Vygotsky's social cultural theory (Vygotsky, 1962) was an attempt to take account of context in terms of language acquisition and usage as well as a rejection of then popular behaviourist theories of psychology (Blunden, 2011). Leontev took these concepts and developed Activity Theory (Engeström, 1999). However, both worked in the old Soviet Union and that meant, at least in public, adherence to Marxist concepts (Blunden, 1997, 2011) in particular of the interaction of human beings and work. Equally, Leontev used an explicitly Hegelian dialectical framework (Blunden, 1997; Sokolova, 2011) with the subject (actor) acting on the object (task) and, in turn, being influenced by that interaction (gaining knowledge, becoming exhausted, creating something new and useful). A further complication lies in the process of translating their work from Russian. The concept of the 'object' is central in Activity Theory but in Russian two different words "*Predmet*" and "*objekt*" are used for this concept (Kaptelinin, 2013; Leontev, 1978). "*Predmet*" in particular tends to refer to an object that was specifically designed to support human activities (Kaptelinin, 2013) while "*objekt*" can refer to any object (ie something that is naturally occurring as well as something specifically constructed by human beings).

As developed by Engeström, some of these concepts were lost or set aside. In effect, Activity Theory became a descriptive framework that could be used to analyse how actors took account of the task, tools and context. To do this, Leontev's model of object, subject and tool was retained (Engeström, 1999) and three more were added:

- *Rules* – either externally set or constructed to regulate a particular situation (so a classroom, for example, has both social rules drawn from society and the rules that pertain to an educational process);

- *Community* – in effect an elaboration on the subject concept to stress that others, not directly carrying out the task, may influence how the task is performed; and
- The *division of labour* – how the tasks are divided among the subject and the community and if there are any vertical divisions in terms of power and status.

Jewitt (2006) adapted this framework to reflect meaning making in the classroom. In her model, the *subjects* are the students and teachers in a classroom, and, in turn, the *objects* are the materials under study or the problem space being constructed. In turn, a *tool* is either the means by which such study is mediated and this can be a physical technical object (a pen, a calculator, a computer) or a mental conceptual mode that is used for understanding. Some aspects fit both criteria so a computer has a physical aspect and “has the ability to transform and reorganise how they deal with intellectual and practical learning” (Jewitt, 2005, p. 24). In combination this gives rise to an activity system, in this case built up as:

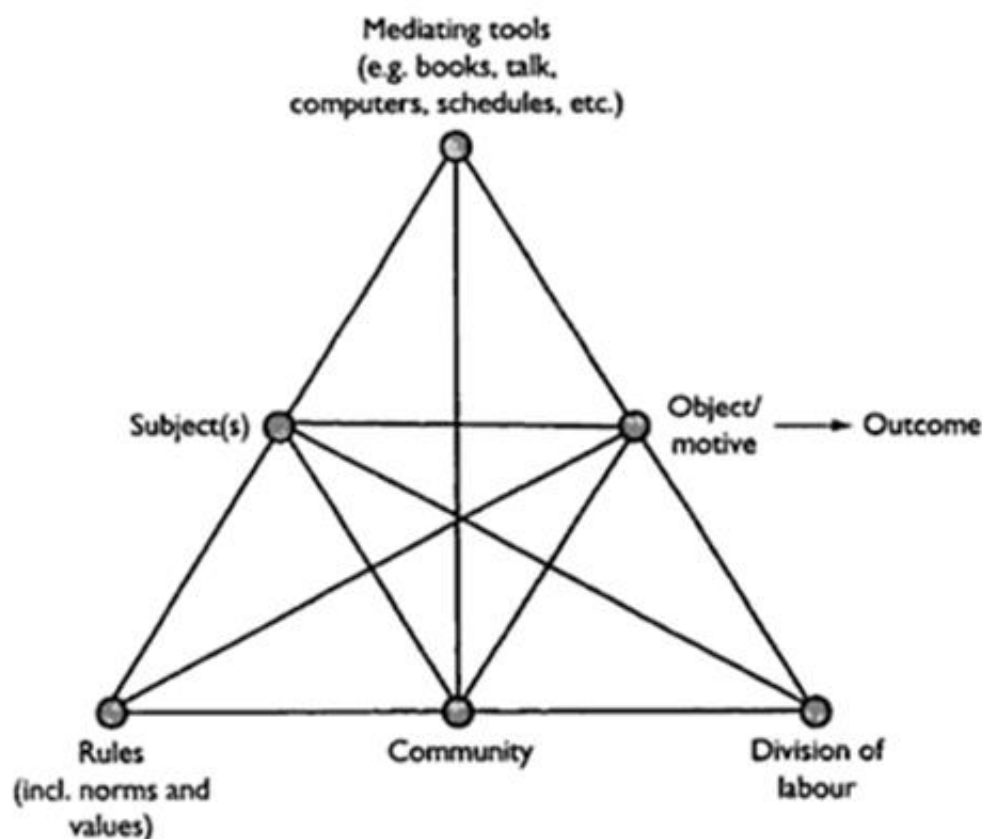


Figure 1: Classroom Activity Systems

In this case, drawing from Engeström (1999), there are also three related social relations at play: the explicit and tacit rules set both by social norms and used in this particular task; the roles assigned to both teachers and students as part of their wider peer and professional groups; and, that distinct roles in learning within the classroom environment (Jewitt, 2006), in other words the tutor-pupil relationship. In combination, this provides a framework that can be used to explore, for example, how changing the tools available might change the meaning making process and their degree of interaction (Donnelly, 2008).

For example, Chernobilsky, et al. (2005) studied the impact of adding an online multimedia resource to a module where students had previously engaged in group learning using traditional learning tools (Chernobilsky, Nagarajan, & Hmelo-Silver, 2005). In the first instance the new tool shifted the form of group dynamics (both the division of labour and the assumed task rules) to a more individualised form of learning as each student interacted on their own with the multimedia

resource. However, over time, the students came to an understanding of both the new tool and the rules for the task that allowed them to return to a degree of in-group collaboration, although they continued to emphasise the need for personal mastery over the learning environment.

Overall, as identified by Jewitt (Jewitt, 2005), Activity Theory provides a useful means to understand context and tool use, but it is less useful as a means to understand how meaning is created and shared. In this context, multimodality offers a means to understand how speech, gesture, tools and other non-verbal communications can interact to build up and modulate meaning (O'Halloran, 2011a).

Unlike Activity Theory, Multimodality does not have a widely agreed representation system. Both the categories adopted and the level of detail varies according to the purpose of the research. In some studies, for example, all semiotics are simply described as verbal or non-verbal (Baldry & Thibault, 2006; Jaipal, 2009) but in others the precise nuance of hand gestures are captured in detail (Xiong & Quek, 2006). Data collection for multimodal analysis tends now to rely on video-recording (Jaipal, 2009; Maher, 2011; Márquez, Izquierdo, & Espinet, 2006). The advantage to video-recording is it allows later transcription and study of the interaction between verbal and non-verbal semiotic usage.

In terms of analysis and representation, as above, the tendency is to adopt a level of detail that fits the research object. Typically, the initial transcription step is to show the interaction between speech and other interventions such as:

Teaching Sequence	Sequence of Modalities
1. Mr. Grant: Okay, Chemoautotroph, the ones that do chemosynthesis. Take a look at 18.11. (He opens book.)	1. Gesture to open textbook and points to visual diagram
2. Many bacteria oxidize energetic inorganic molecules.	2. Verbal narration and written declarative statement on chalkboard
3. What does it mean to oxidize something? How many of you are taking chemistry? What does oxidize mean?	3. Verbal interrogative questions to reorient students thinking and elicit meaning of oxidation
4. Student 1: From metal to rust.	
5. Mr. Grant: Does that release energy or use energy? [pause]	
6. Student 2: Release.	
7. Student 3: Both.	
8. Teacher: It releases quite a bit of energy. (moves both hands outward in a wide circle). You know the perfect example of that.	Verbal comment and gesture to reinforce meaning of oxidation
9. Think of a sparkler. You know those long sticks at Halloween—sparklers—they burn incredibly hot with sparks coming off (moves hand in circles). That's iron burning! Releases a lot of energy and what does it turn to when the stuff falls onto the ground—little particles of rust (makes small circles with fingers).	4. Visual recall imagery of action evoked by gestures, descriptive phrases, and narrative

(Source: Jaipal, 2009, p. 57)

Figure 2: Integration of Speech and other semiotic resources

This approach can be made more complex with the addition of video stills such as for this political interview (O'Halloran, 2011b):

Stage	'Petrol Prices'									
Phase	Leaked Cabinet Documents									
Sub-Phase	Leaking Documents as Legal Issue					Leaking Documents as Political Issue				
	SHOT 1	SHOT 2	SHOT 3						SHOT 4	SHOT 5
Salient Visual Frame										
	Frame 1	Frame 2	Frame 2	Frame 4	Frame 5	Frame 6	Frame 7	Frame 8	Frame 9	Frame 10
SEMIOTIC RESOURCE:										
Speech:										
Speaker 1 - Tony Jones (interviewer):	Alright, Tony Abbott	you've been in the trenches. That's fair enough isn't it?			* yes, a little - a little bit like the coalition.	Leaking going on all round				
Speaker 2 - Tony Abbott:		Ah, yes it is	but the interesting thing is that the new government is already	leaking, Tony. I mean normally it takes many years	* before a - before - before a government	... well I - Tired old governments	leak. New, smart, clever,	intelligent governments aren't supposed to	leak, and the fact that this government is leaking so badly	so, early is a pretty worrying sign.
Kinetic Features:										
Gaze:	off-screen; engaged; directed at interviewer	off-screen; engaged; directed at Tony Abbott	off-screen; disengaged; directed at self	off-screen; engaged; directed at studio audience/interviewer/Tanya Plibersek	off-screen; engaged; directed at studio audience/interviewer/Tanya Plibersek	off-screen; engaged; directed at camera/viewer	off-screen; engaged; directed at studio audience/interviewer/Tanya Plibersek	off-screen; engaged; directed at studio audience/interviewer/Tanya Plibersek	off-screen; engaged; directed at Tony Abbott	off-screen; engaged; directed at studio audience/interviewer/Tanya Plibersek
Body Posture:	angled	angled; leans forward toward Tony Abbott	angled; leans back	angled	angled	straight	angled	angled	angled	angled
Gesture:			raises hand; palm facing outward	raises hand; palm facing outward	hand raised; palm facing outward	both hands raised; palms facing outward/each other	both hands raised; palms facing outward/each other; gap narrowing	both hands raised; palms facing outward/each other; gap narrowing		both hands raised; palms facing outward/each other at reduced distance; downward movement
Cinematography:										
Camera Angle (horizontal perspective)	oblique/detached	oblique/detached	oblique/detached	oblique/detached	oblique/detached	frontal/involved	oblique/detached	oblique/detached	oblique/detached	oblique/detached
Size of Frame	medium close-up	medium close-up	medium close-up	medium close-up	medium close-up	medium close-up	medium close-up	medium close-up	medium close-up	medium close-up

(Source: O'Halloran, 2011b, p. 17)

Figure 3: More complex interaction of speech and other semiotic modes

Here visual images are added, in addition to speech transcription and a description of non-verbal elements such as direction of gaze, body posture and any gestures in use. However, this still leaves problems in terms of analysis. In effect, both the simpler layout (Jaipal, 2009) and the more complex (O'Halloran, 2011b) are essentially descriptive, telling us what happened and when. They do not tell us how meaning was constructed and conveyed.

To achieve this it is necessary to allocate speech, gesture and other non-verbal aspects into categories. These categories can be simple, perhaps naming the tools and approaches used or designed to break down speech into a range of categories. Hmelo-Silver et al (2008) identified four modes of talk that they then used to categorise each exchange as:

Table 1: Example of the coding structure

Category	Example
Content	
Task talk	I recommend that you spend a bit more time on discussing EACH proposal and then vote let's say late afternoon on Tuesday
Tool-related	Frank and I decided instant messenger may be useful for discussing comprised info and ideas
Concept talk	Elaborative rehearsal better equips the student with the information he is rehearsing because it becomes more accessible in his long term memory he has found ways to relate it to other instances and in his own words and he can help his peers understand it on a more simple level
Personal talk	Hey, I just wanted to let everyone know that I will might be a little late logging in on Monday morning. I will be in Connecticut until early Monday morning

(Adapted from: (Hmelo-Silver, et al., 2008, p. 417)

These categories can be broad based or fine grained as needed to support a given research enquiry. A different focus that stressed the purpose and location of the interaction was offered by (Márquez et al, 2006), as:

- *“Thematic space (TS). Every meaning that is related to the topic under study, every process that gives meaning to conceptual aspects. So our thematic space is water circulation in nature.*
- *Classroom management space (CMS). Every meaning that relates to organization of the classroom as a communicative and social space where it is necessary to organize participation, time, order of the interventions etc.*
- *Representation management space (RMS). Every meaning that relates to the strategies used by the teacher to help students construct a water cycle diagram” (Márquez et al, 2006, p. 208).*

These in turn were subdivided into the processes that made up the classroom interaction ranging from aspects of the science being taught to how the students were being controlled.

The final stage of any analysis is to move beyond a coding system to presenting the data. Here a common tool is simply counting instances and comparing them to the situation. This has the advantage of relative simplicity and it is possible to see how different semiotic modes may be adopted by different actors or in different situations. Thus the schemata above was applied as:

	Kind of Process	Speech	Gesture	Visual Language	Written Text	Total	Total Semiotic Space
Thematic space	Processes related to properties and characteristics of water in nature	156	5	33	0	194	
	Processes related to water changes and causes of water circulation	212	70	37	0	319	513
Classroom management space	Processes related to the control of students' participation	75	81	0	0	156	156
Representation management space	Processes of naming water cycle entities	87	0	0	70	157	
	Processes related to the management of water cycle diagram	276	103	1	12	392	773
	Mental processes	182	32	1	9	224	
	Total	988	291	72	91	1442	1442

(Source: Márquez et al, 2006, p. 214)

Figure 4: Usage of different modes for different roles

This for example allows an understanding of when speech was the most frequent mode of delivery and how different modes of delivery were used to sustain different processes. This is useful and effective as a means to represent shifts of multimodal meaning making across long sessions. However, what is missed is how different modes interact over time. This requires making use of something akin to O'Halloran's (2011b) approach but with the coding structure imposed onto that essentially descriptive framework.

This leads to the core problem of multimodal research. If the goal is to do more than simply count instances any reporting is complex as it needs to present the original evidence (words, images etc) alongside a coding structure and discuss how meaning making alters over time. This detailed coding is essential to reflect the process of inter-semiosis to show how different modes interact (which is dominant, are they complimentary or contradictory?). However, the concept of re-semiosis tends to be lost as it is rarely discussed as a coding category.

These concerns are one reason why the combination with Activity Theory can be so rewarding (Jewitt, 2005, 2008). Using AT means that the focus on re-semiosis is not lost in the detail of coding multimodal meaning making. Equally AT, along with the simpler counting approaches in MDA, provides an overview of a long session of meaning making. From this overview, it is possible to then identify a number of short excerpts that can be used to exemplify the detailed interaction of semiotic modes in the meaning making process. In turn, multimodality allows a focus on how meaning making is carried out as opposed to the focus on who is involved, what tools they use and their purpose which is the core of AT.

Research Context:

This study looked at problem solving by students taking an engineering degree course. Some of the classes were delivered using the pedagogy of problem based learning (Hmelo-Silver, Chernobilsky, & Jordan, 2008; Savin-Baden & Major, 2004). Student interaction with each other (a group of five students) and with the module facilitator was recorded over five separate sessions (each lasting from 40 to 70 minutes). The goal of the module was to design a bridge that would cope with a set level of stress using prescribed materials (basic short wooden sticks and glue). The class had more than one student group present and some of the tutor's interaction was with the whole class rather than the group that had agreed to be observed. The first three sessions involved all five students. They started with a focus on the theory behind bridge design and the necessary mathematical knowledge. This shifted to consideration of the practicalities of building a bridge with the particular constraints set by the module. The fourth session involved two of the students working out how to design the model. The final session featured all the students discussing this initial model with the tutor and what changes were needed to ensure the bridge would meet the required criteria.

Research Design:

Each of these sessions was videotaped and the first step was then to transcribe the results. This first step, following Jaipal (2009) was descriptive, including stills from the video and a transcript of the speech and gestures of each of the six potential actors (the five students and the facilitator). This basic resource, combined with reference back to the tapes as needed, became the underlying data source for both strands of the analysis.

The first stage in analysing the results was to describe the sessions in terms of Activity Theory. A typical example of how this was done, from the first class, is set out below:

Table 2: Coding of Interaction (AT)

Timing	Description	Object	Subject	Tools	Rules	Community	Division of Labour
10.15-11.10	Discussion of possible solution between individual students		1:1 discussions	calculator			Discussion led by 1 student
11.10-11.30	Checking understand and possible solutions		1-1 discussions	Paper, written notes			
11.30-12.55	Working on solution		Individual work	calculator			
12.55-13.05	Tutor input		Student work carries on	Reference to text book		Facilitator led	
13.05-13.45	Student work		Mostly individual work				

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The time blocks were selected so as to represent coherent periods so for example there was 10 seconds of tutor input (12.55-13.05) followed by a return of the students to working by themselves. Each is coded to reflect the object (where this changed), subject (and how the students were interacting), tools, rules, actions by the wider community and any evidence of a division of labour within the core student group.

The next stage was to code the entire transcript in terms of the multimodal resources used. In the classroom context, Hmelo-Silver (Chernobilsky, et al., 2005; Hmelo-Silver, et al., 2008) identified five modes of meaning making, as:

1. Content of the talk;
2. Collaboration;
3. Responses of ideas/complexity;
4. Knowledge;
5. Metacognition

Each of these broad categories was then broken down into sub-categories so content could be about the task in hand, the tools available, the broad theoretical concepts or personal discussions as:

Table 3: Coding of content of talk

Category	Sub-Categories	Example
Content of the Talk	Task-related talk (TT)	Keep to those specifications guys
	Tool-related talk (TR)	you need to know what your calculator is doing.
	Concept-related talk (CT)	you can use the resolution of forces too
	Persona talk or general social issue (PT)	Listen guys, if I just uh, have your attention please,

The examples on the right hand side are drawn from the transcripts as examples of each sub-category. Collaboration was broken down into multiple categories and captured if it involved a new idea or an elaboration, agreement, disagreement or acknowledgement of an idea raised by someone else. It is also involves questioning and the facilitator's interventions.


Hmelo-Silver's list was supplemented by the concept of internalisation to capture who was leading meaning making (the students or the tutor) and scaffolding (Hill & Hannafin, 2001; Stålbrandt, 2007) to explore the process of learning. Scaffolding is a key part of the PBL process as it reflects ways in which learning is guided by presenting a framework but without supplying a direct answer. Here, five modes were used as:

Table 4: Coding of Scaffolding

Category	Example
Conceptual Scaffolding (CS)	that I've seen in my experience have been what I call box-shapes
Metacognitive Scaffolding (MS)	in order to get the result in force you need to know the angle too
Procedural Scaffolding (PS)	8.6 squared plus 7.4 [background noise] and the square root of all these
Strategic Scaffolding (SS)	so you could actually stand on a wire frame structure.
Technical Scaffolding (TS)	and he's used the cosine, sine and cosine and in order to work out the resultant

Using these codes, every aspect of the five classes was coded and a typical example of the final analysis, drawn from the end of the first class was:

Table 5: Example of the multimodal analysis structure

Time	The verbal semiotic resources (Speech)	Other Synchronous non-verbal Semiotic Resources	Their Category							
			Content	Collaboration	Responses of ideas/	Knowledge	Metacognition	interpretation	Internalization	Scaffolding
54.21	Okay boys can I have your attention please,		PT	FM	BA		GM		IFS	
		Students A and B are fiddling with the paddle sticks	PT							
	Facilitator: we're just going to do some of the tricks.		TT	FE	ET			IL		
		Facilitator – gesticulates and shows paddle pop sticks 	TR	FT						TS
54.29	Facilitator: So the tricks are in terms of strength.		CT	FE	ET			IL		
		Facilitator gestures with his hands to indicate the type of pressure that will be placed on the bridge	CT	FE						MS
	Facilitator: What you don't want to have		CT	FE	ET			IL		MS
	Facilitator: is the bridge sort of buckling underneath your load springy		CT	FE	ET			IH		

So in this case the left hand column shows the time and can be related back to the detailed reports. Speech is broken down into small excerpts and each is coded, as appropriate. The non-verbal resources are linked into this flow of speech. In some cases a purely descriptive approach has been adopted and in others a video still image has been added to exemplify

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what is being described. This allows a reading of the flow of meaning making, where it shifts from the task to content, who is leading the meaning making and how the verbal and non-verbal elements interlink (which dominates, when are they complimentary, when are they contradictory).

However, as discussed, making use of the material (apart from counting) is complex and can only be reported for short periods especially as the goal was to study inter-semiosis and understand if particular modes of meaning making were dominant. In this research, seven sessions were identified that typified key dynamics within the class. They were used to explore the detailed question of how meaning making was conducted, as:

Table 6: Selection of excerpts for closer analysis

Excerpt	Video-Taped Session	Time	Focus
1	1	1.25-4.00	Facilitator led, focus on the theory behind the bridge design task
2	1	24.27-27.38	Interaction within the student group, focus on the theory behind the bridge design task
3	1	54.21- 56.27	Group-Facilitator discussion, shift of focus from the theory to the model building task
4	2	30.50-36.15	Interaction within the student group, followed by a group-facilitator discussion, shift of focus from the theory to the model building task
5	3	08.26-13.10	Shifts from student group, to facilitator input to group-facilitator discussion. Most of the focus is on the theory behind the bridge design
6	4	19.47-23.26	Two of the students discussing how to build the model
7	5	22.20-26.44	Group-Facilitator discussion focussed on the model designed between sessions 4 and 5

3. FINDINGS

The first stage to the analysis was to use Activity Theory and understand the dynamics in those terms. This noted there were two related contexts that framed the work undertaken by the students. The first was the academic discipline (Engineering) and the theoretical issues connected with building a bridge. The second part of the context was this particular academic module. This framed the student meaning making by setting the task, the timescale and the resources as:

“What you’re going to do is to build a bridge or a tower out of these paddle-pop sticks. You’re only allowed to use the paddle-pop sticks or the glue. So the first thing that I want you to think about is how you’re actually going to get a strong structure. Think back to that wire frame job” (35.59, facilitator input, session 1).

However, there was also evidence that this framework was not shared between the facilitator and the students.

- First, the students quite often query or seek clarification of the rules and the timescale for the task (this may reflect a search for clarity, forgetfulness or a lack of acceptance of the framework set out);
- Second, there are instances where the students explicitly state they lack clear information or would prefer to not be engaged in the classic PBL task structure (an example is in session two: *“The teachers, they haven’t taught us anything but she just expects us to know all this crap. What does this... mean”*). Similarly there is the statement in session 4 *“I want questions and answers”* which again can be read as indicating a desire for information that will ease the process of task completion. Later in session 4, the students lose focus on the model building task and by both speech and gesture indicate frustration or confusion with the task.

These instances are not definitive, but taken together do indicate that the students know the rules for a PBL style task environment but have reservations about the application. In effect, that there are two sets of rules in operation, those of the academic process and those preferred by the students. In Activity Theory terms this indicates that in some respects the focus and meaning of the task are agreed and in others there is disagreement (or at least a lack of shared agreement). The

classic Activity Theory diagram can be used to set out the various categories from the perspective of the facilitator (in black) and the students (in red), as:

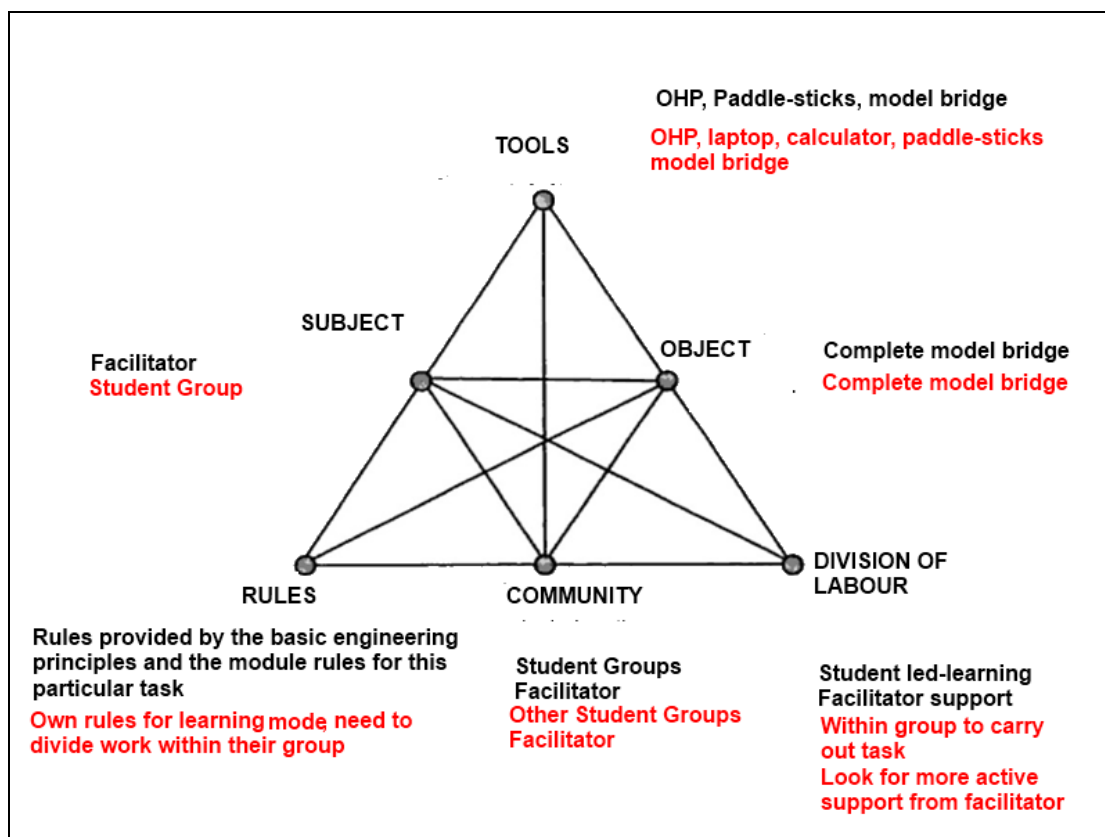


Figure 5: Student and Facilitator task understanding

In addition, using AT meant it was practical to spot that students rarely made use of the whole group learning approach that is the core to PBL and instead reverted to individual or sub-group learning and discussion. One issue that the AT analysis left unclear was whether the facilitator was part of the subject (ie active within the student group) or the community (ie part of the wider world the student's interacted with). Thus the multimodal analysis was used first to explore how meaning making took place and second whether or not the facilitator used similar approaches to the students.

The first step was to take the seven excerpts identified and break each down into smaller blocks (usually of 1-2 minutes). A new block meant that either the focus of meaning making had shifted or another significant change had occurred. In turn, each sub-section was coded in terms of the underlying interaction (the facilitator to the entire class, the facilitator and the student group, the student group alone), whether they were discussing the underlying theory or the practical bridge building task and whether meaning making was dominated by the facilitator or the students. This gave a structure as:

Table 7: Session codes

Excerpt	Class	Time Frame (of whole Excerpt)	Focus	Theory or Model Building	Dominated by
1	1	1.25-4.00	Facilitator Presentation (Whole class)	Theory	Facilitator
2	1	24.27-27.38	Student Interaction	Theory	Students
2	1	24.27-27.38	Student Interaction	Theory	Students
2	1	24.27-27.38	Student Interaction	Theory	Students
3	1	54.21-56.37	Facilitator Presentation (PBL group)	Model Building	Facilitator
3	1	54.21-56.37	Facilitator Presentation	Model Building	Facilitator

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			(PBL group)		
3	1	54.21-56.37	Facilitator Presentation (PBL group)	Model Building	Facilitator
3	1	54.21-56.37	Facilitator Presentation (PBL group)	Model Building	Facilitator (some student involvement)
4	2	30.50-36.15	Student Interaction	Theory	Students
4	2	30.50-36.15	Student Interaction	Theory	Students
4	2	30.50-36.15	Facilitator Presentation (PBL group)	Model Building	Facilitator (some student involvement)
5	3	08.26-12.51	Facilitator Presentation (PBL group)	Theory	Facilitator
5	3	08.26-12.51	Facilitator Presentation (PBL group)	Theory	Facilitator
5	3	08.26-12.51	Facilitator Presentation (PBL group)	Theory	Students (some facilitator involvement)
5	3	08.26-12.51	Facilitator Presentation (PBL group)	Theory	Students
6	4	19.47-23.26	Student Interaction	Model Building	Students
6	4	19.47-23.26	Student Interaction	Model Building	Students
6	4	19.47-23.26	Student Interaction	Model Building	Students
7	5	22.20-26.44	Facilitator Presentation (PBL group)	Model Building	Facilitator (some student involvement)
7	5	22.20-26.44	Facilitator Presentation (PBL group)	Model Building	Facilitator (some student involvement)
7	5	22.20-26.44	Facilitator Presentation (PBL group)	Model Building	Facilitator (some student involvement)

This structure allowed consideration of how the semiotic resources varied as the task developed, between verbal and non-verbal resources and between the students and the facilitator. This structure allowed a detailed investigation of how different semiotic resources were used as the task changed. One example was to study how verbal and non-verbal resources were used between the theory building and the model building sessions as:

1. In one of the theory building sessions, speech was dominant to the extent that the non-verbal elements are simply pointing or recording the information. Overall this was the most common situation;
2. In the second theory building session, speech was again dominant but this time the non-verbal gestures are used to emphasise the spoken meaning (especially about the direction of the forces and the nature of 'compression');
3. In the first model building session, the non-verbal elements were dominant. Meaning making is driven by the arrangement and re-arrangement of the paddle sticks and speech is used as a 'filler' or to verbalise the gestures. Again this reliance on non-verbal meaning making was dominant in the model building sessions;
4. In the second model building session, there is more of a balance between the role of verbal and non-verbal elements in meaning making. In this case, speech is dominant (ie it is used to set out the meaning intended) but heavily dependent on arranging the model to exemplify what is meant or pointing at the model to indicate where the problems are.

Overall it was clear that:

- The students use different semiotic resources when dealing with the theoretical concepts as opposed to the problem of building a model bridge. The former is dominated by concept-related talk and the latter by elaborated explanation as they engage in more open discussion;

- The dominant mode (Iedema, 2003) between verbal and non-verbal semiotics varies. In the theoretical sessions, speech tends to dominate but in some instances non-verbal gestures and tools are essential to support the meaning making. In the practical sessions either there is a balance in the importance of the two modes or in some instances the non-verbal mode is dominant and speech used simply to vocalise the meaning that is being constructed using gesture and the tools;

This allowed a conclusion that the mode of meaning making did shift as the task changed from theory to practice as:

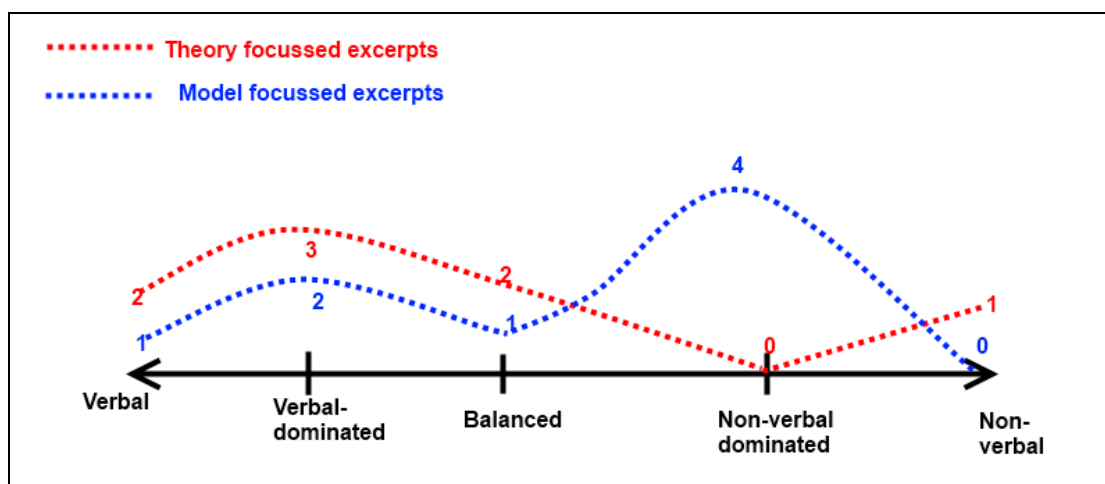


Figure 6: Shift of dominant mode in student meaning making

When the focus was shifted to how the facilitator interacted with the students, one aspect was in terms of complexity.

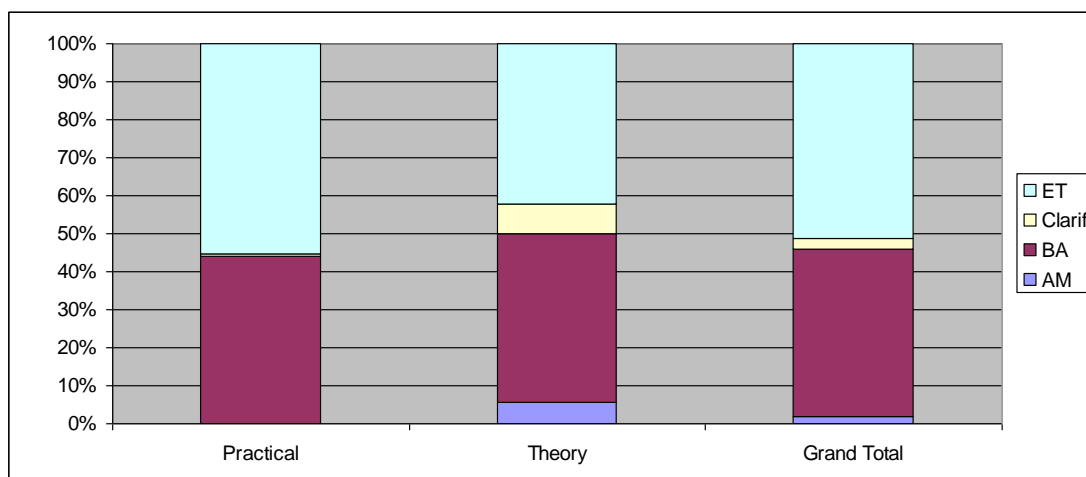


Figure 7: Complexity of the Facilitator's speech

Here ET (extended telling) dominated and BA (brief agreement) was relatively rare. In effect when he answered a student question he did so by providing additional information rather than simply answering the question. Overall it was concluded that compared to the students, he:

- Makes more use of collaborative speech;
- Very rarely uses simple agreement;
- Makes substantial use of complex interpretation; and
- Makes substantial use of scaffolding.

All these indicate that he is taking a different role in the PBL task to the students.

4. CONCLUSIONS

In summary the two techniques worked effectively in combination. Activity Theory meant it was easier to concentrate on the context (re-semiosis) than is often the case in multimodal studies. Equally it was useful to pinpoint the shifting membership of the 'subject' and identified the question as to the real role of the facilitator. In turn, multimodality was essential to understand how the meaning making and task performance was carried out. This strand allowed identification of how the students shifted their style of meaning making as the task developed and confirmed that while the facilitator worked with the student group he was not part of that group. His use of semiotic resources indicated a role of guiding their actions, often providing new questions for them to consider and, on occasion, stressing the importance of the task framework.

This does leave several questions. The first is whether it would have been feasible to have simply used a multimodal approach and perhaps have selected specific sessions from a simple overview of the tapes. In response, it is worth stressing that Activity Theory added something new to the process (the shifting nature of the task and actions) and specifically forced attention to the issue of how context influenced the task. Equally the individual sessions were identified as, in Activity Theory terms, they were different in style of interaction (between individuals, with tools or as to purpose). This meant the excerpts were selected with a very deliberate purpose.

The second issue is that information gathering stopped when the tapes were complete and at that stage the process of codification began. Other research designs that look at the multimodal nature of student learning supplement the recorded information with interviews (Airey & Linder, 2009; Moreno & Mayer, 2007). Such additional information would have been valuable in this instance to explore several issues:

- Did the students feel prepared for the task (there are isolated instances where they indicate a lack of understanding about the theoretical underpinnings and about the task requirements)?
- Did the students believe they had carried out the task as required (in particular to explore the difference between the layouts tested in session four and the actual model presented in session five)?
- Did the facilitator have confidence in the student performance on the task (and was this expected. There is evidence in his long presentation in session 3 that other student groups have performed much more successfully)?
- Was he aware of the directive nature of his interventions with the students (and again was this by design or in response to their difficulties with the task)?

In this respect, the practicality of the research timescale dominated. It was necessary to first code and analyse the tapes before it would have been useful to have carried out any interviews. In this case, a new academic year commenced before it would have been feasible and by that stage the student group had dispersed and the tutor involved with a new class.

Overall, the exploration of this process is enriched by the reliance on both Activity Theory and multimodality. Activity Theory can overview the meaning making process in a holistic manner and proves useful for an understanding of the context and rules. Multimodality is invaluable to understand how both the facilitator and the students undertake the meaning making task using different semiotic modes as the task evolves.

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